DIRECT IMAGE VIEWER,
SPECIFICATION FOR

25 August 1964

DIRECT IMAGE VIEWER, SPECIFICATION
for

1.0 SCOPE

1.1 This specification describes the performance and technical characteristics of an Experimental Direct Image (High Resolution) Viewer. The Direct Image Viewer employs a unique optical approach, involving diffraction gratings, to provide an observer with an enlarged aerial image which can be viewed simultaneously with both eyes.

1.2 Major features of this viewer include the elimination of performance limitations imposed by the use of rear projection diffusion screens, and the achievement of high magnification viewing qualities comparable to advanced microscope viewing objectives.

2.0 APPLICABLE DOCUMENTS

2.1 The following drawings form a part of this specification:

STATINTL

[redacted]	Dwg. No. 7506L1	Layout Dual Magnification, Direct Image Viewer
	Dwg. No. 7506L2	Assembly, XY Translator, Direct Image Viewer

3.0 REQUIREMENTS

3.1 Design - The overall configuration of the Experimental Direct Image Viewer specified herein shall be in general conformance with [redacted] Drawing No. 7506LSTATINTL The viewer shall employ materials of highest commercial quality consistent with its intended performance and specified operating environments.

3.2 Performance Characteristics - The performance characteristics of the Experimental Direct Image Viewer shall consist of the following general values:

3.2.1 Magnification - Dual individual magnifications of 5X and 50X.

3.2.2 Observable Film Area - The observable film area shall consist of a nominal two (2) inch by two (2) inch square area in the film plane at 5X magnification, and two-tenths inch by two-tenths inch square area in the film plane at 50X magnification.

3.2.3 Film Size - The viewer shall possess a capability for viewing single frames of either 70mm or 4 x 5 inch film chips.

3.2.4 Exit Pupil Size - The nominal size of the composite exit pupil shall be 3.5 inches square.

3.2.5 System Resolution - At 5X magnification, the Experimental Direct Image Viewer shall be

capable of providing a system AWAR resolution of 60 lines per millimeter over the used field when referred to a high contrast target in the object plane. At 50X magnification, the viewer shall be capable of providing an on axis resolution of 200 lines per millimeter at the film plane with a high contrast target while employing commercially available lens. The resolution goal of the system when operating at 50X shall be 200 lines per millimeter as viewed in the object plane for a low contrast (1.6:1) target.

3.2.6 Light Intensity - The illumination system shall be variable and will present to the eye, with an open film gate, at least that amount of light flux as presented to the eye by a lambertian source with illuminance of 100 ft-lamberts.

3.2.7 Illumination Spectrum - The illumination of the viewer system shall be contained in a narrow portion of the spectrum centered around 508.6 millimicrons.

3.2.8 Film Positioning - The viewer shall incorporate a provision for remote film positioning through X and Y translations to permit full coverage viewing areas for either 70mm and 5-inch film chips.

3.2.9 Focusing - A manual fine focus control shall be provided for each viewer lens magnification.

3.2.10 Film Temperature - The temperature of the film when mounted in the film plane of the viewer during operation shall not exceed ambient ($75^{o}F$) by more than $20^{o}F$ at an average density (silver) of 0.8.

3.2.11 Viewer Controls - The Experimental Direct Image Viewer shall contain a set of viewer controls, front panel mounted, consisting of the following:

3.2.11.1 Power - ON/OFF

3.2.11.2 Intensity of Illumination

3.2.11.3 Magnification Selector, 5X and 50X

3.2.11.4 Lens Focus, 5X and 50X

3.2.11.5 Film Translation
± one inch X
± one inch Y

STATINTL

3.2.12 Physical Size - (Reference [redacted] Dwg. No. 7605L1). The viewer shall consist of the following general dimensions: Length - 66 inches, height - 26 inches width - 29 inches.

3.3 Theory of Operation - In direct viewing optical instruments, such as a microscope, the exit pupil is small, requiring that the operator place his eye close to the eye piece for satisfactory viewing. The present Experimental Direct Image Viewer, with its larger optical elements and diffraction grating, enlarges the exit pupil in a manner that the operator may view with both eyes the image and still have adequate head movement. In the absence of employing diffraction gratings in the present viewer, a single small exit pupil would exist, which would restrict the operator to the use of a single eye and no head movement when viewing at high magnifications. Through the insertion of the gratings in the optical path, and the use of a narrow portion of the spectrum, many exit pupils are created, which when arranged side by side and placed both above and below one another, form a matrix of exit pupils in space providing an effective viewing area of 3.5 inches square, where the operator may place his eyes for viewing. This unique approach results from the use of a special field lens, and specially designed and built set of diffraction gratings. Near monochromatic light must be used in

the viewer, or the diffraction characteristics of the gratings will produce a rainbow of images between matrix units (exit pupil images).

3.4 Technical Details

3.4.1 Viewing body, optical supports, and controls -

3.4.1.1 Chassis - The viewer frame will be constructed from aluminum jig plate, and rigid mounts will be supplied for all optical elements. The large field lens will be of a split design, and flange mounted to a one-inch thick plate. The diffraction gratings will be mounted between the field lens elements and their one-inch separated flanges.

STATINTL

3.4.1.2 Film support and X-Y translation - The film support system, as shown in [redacted] Dwg. No. 7506L2, accommodates both 70mm and 5-inch film chips. The film will be held by a vacuum to a flat glass plate free of striations. The glass platen will be mounted on a mechanical mechanism which will provide controlled X and Y movement of 2 inches and translate the film 9 inches in X to change magnification.

STATINTL

3.4.1.3 Objective Lens Mounting - The two lenses will be flange mounted with the position of the flange being manually adjustable for fine focus.

3.4.1.4 Auxiliary equipment -

(1) The light source power supply will be packaged and included with the viewer.

(2) A connection will be provided for external vacuum.

3.4.1.5 Viewer Housing - The viewer housing and enclosure will have a hinged section at the rear for access to the mechanism and for inserting film and lamp replacement. The front panel will contain the controls and provide the proper mask around the field lens and gratings.

3.4.2 Viewer Optics

3.4.2.1 Field Lens - A symmetrical design multi-element, 15-inch diameter, field lens will be used. The lens will image the exit pupil of the objective lens 20 inches from its rear nodal point. The lens shall be of a sufficiently high quality as not to degrade the high resolution image requirements of the viewer.

3.4.2.2 50X magnification components - A large aperture photographic lens will be used with a modified exit pupil producing a square opening. The resolution of the viewer is dependent upon this lens, and the best commercially available lens with an f number approaching unity will be used.

A multi-element condensed system will be used to concentrate the light to the small 0.2 x 0.2 inch square film area while filling the objective lens.

Field flatteners shall be employed to provide field curvature for optimum field lens operation.

3.4.2.3 5X Magnification Components - A commercially available 8.5 inch focal length lens will be modified to contain a square exit pupil equal in size to the 50x lens case.

The condenser system to be employed with this lens will concentrate and illuminate a 2 x 2 inch square area evenly.

Separate field flatteners will be used for the same purpose employed with the 50X system.

Two additional small mirrors will be inserted in the path, one before and one after the lens to provide the dual 5X magnification. The mirror in front of the lens is movable to permit inserting it or removing it from the optical path. With film translation, the two magnifications are obtained.

3.4.2.4 Light Source - Two lamps and reflectors shall be employed, one for each lens. In addition, special interference filters will be employed to provide the narrow spectrum required.

3.4.3 Diffraction Grating - In order to obtain the unique optical multiplication of exit pupils required, special diffraction gratings are required. Two gratings are employed to diffract the light into a multiplicity of exit pupils dispersed in two directions 90^{o} apart, thus providing a matrix of exit pupil images.

3.4.3.1 For the prescribed magnification levels and the size of the multiple exit pupil required, a minimum of thirteen (13) orders of diffraction are required, a central order and six (6) on each side. The difficulty of the grating design is that all orders should receive the same amount of energy so that each exit pupil appears of the same brightness to the observer.

3.4.3.2 The gratings shall be of a 10 x 10 inch ruled surface, which influences the field of view of the system and the observable film size. Special ruling techniques are required and will be used to produce these gratings.

3.4.3.3 The light is diffracted by one grating in one direction, and then each diffracted exit pupil is spread out in the other direction by a second grating. The cascaded diffraction gratings produce a decrease in light intensity, which is then enhanced by the use of a narrow band light source. Compensation is provided in the condensers, high intensity lamps and the small f/number projection lens at the high magnification.

3.4.3.4 The nominal angular deviation, of the central ray in each exit pupil of the various orders shall be:

First order	48'
Second order	1°36'
Third order	2°25'
Fourth Order	3°13'
Fifth order	4°1'
Sixth order	4°56'

The tolerance for each of the above deviations shall be ±10% of the above angles.

3.4.3.5 Intensity variations throughout the nine orders shall be no greater than 40% between adjacent orders and no greater then a 2:1 ratio between the lowest and highest order in the nine central orders.

3.4.3.6 The transmission of the order which transmits the minimum amount of light shall be at least 3% of the light intensity falling on an individual grating.

3.4.3.7 The glass quality to be used in the manufacture of the diffraction gratings shall be greater than striae free through the faces.

3.4.3.8 A maximum of 10 arc minutes of slope error shall be a permissible planeness (figure) of the glass.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 The optical components will be inspected and tested to demonstrate compliance to the performance requirements stated in Section 3.2.

4.2 The diffraction gratings will be inspected and tested to show compliance to the performance requirements stated in Section 3.2

4.3 A set of complete viewer acceptance tests will be conducted to demonstrate satisfactory operation of all the functions and specifications stated in Section 3.0.

5.0 PREPARATION FOR DELIVERY

This viewer will be packaged and prepared for shipment and delivered in accordance with accepted commercial practices.

6.0 NOTES

None

STATINTL

9. Film Temperature : max 20°F over ambient 78°F with 0.8 density film.

a. Check out Temp Potentiometer [redacted]

b. obtain 0.8 density film.

(We really need a POP for research on means of measuring the actual temperature the film undergoes)

10. Size: L = 66 "
h = 26 "
w = 29 "
} Measure

11 Angular deviation tolerance of ± 10% of nominal grate diffraction grating orders : how measure?

12. Intensity variations between central orders :
40% between adjacent,
< 2:1 ratio between lowest & highest.

13. Minimum transmission of any one order:
3% : (use ft-candle meter?)

14 Planeness of glass = 10 arc min slope error: what means how measure

Virtual Image Viewer

STATINTL

~~Question #2~~ Test

[redacted]

STATINTL

1. Magnification (5x + 50x) : how measure? [redacted]

2. Film size : either 70 mm or 4"x5" : what means?

STATINTL

3. Exit Pupil 3.5" square : how measure [redacted]

4. Check MIL-STD 150A for AWAR and techniques for calculating (60 l/mm AWAR at 5X)

5. Requirement: 50x = 200 l/mm high contrast
   Goal : 50x = 200 l/mm low contrast (1.6:1).
   (Need each type of target)

STATINTL

6. Light Intensity spec: Lambertian, etc
   100 ft-lamberts : how measure? [redacted]

7. Lt. Spectrum : 508.6 millimicrons : how measure

STATINTL

[redacted]

8. ¶ 3.2.3 + 3.2.8 conflict = 4"x5" vs. 5" chips

HIGH CONTRAST

8/2 on optic	8/2	8/3		354-397
NE	6/5	6/6,	6/6	139
NW	7/4,	7/5	, 7 4	250
SE	7/3	7/3	7/3	198
SW	7/3	7/1	7/3	198

LOW CONTRAST

on	7/4	7/5	182-205
NE	7/1		128
NW	7/3		163
SE	7/3		163
SW	7/2		144

2-2/3/66 997094

[redacted]

missing orders in ruled (blazed) gratings
- so EDL to photographic technique
good dispersion, but flatness critical

STATINTL [redacted] minoflat : [diagram] 9μ

(harmonic generation)
flickering, aided by 20% ratio [diagram: 1 5 1]

STATINTL [redacted] would take over research (into emulsion technology etc) + production

STATINTL [redacted] microcircuit work in micro-patterns

blank proj

STATINTL [redacted] STATINTL

[redacted] Electronic Systems + Training Devices

Apollo Program virtual image viewer request

Thru [redacted] ?

STATINTL [redacted] STATINTL

[redacted] viewfinder at [redacted]

8" is "O"; 4-5" is "I"

STATINTL

[Colorvision bankrupt - [redacted] trying to buy patent

[redacted] peaking viewers]

Ship viewer before March 31; K.F. + B.M. will come week of April 11

rotating grating w. 2nd set of optics ?

GAI 3D virtual image flight simulator ? - HOT

968-6381

STATINTL

[redacted]

STATINTL

2" grating to [redacted] 6" eye lens

light transmission good

multiple images w. high contrast, but no secondary images (apparently) outside viewing area

9-10% transmission (better than 4% of [redacted] lenticular screen viewer at present)

STATINTL

STATINTL

report to [redacted] after March 20 when last lenticular delivered by [redacted] form

STATINTL

~~Oct~~

delay after airfreight arrival in [redacted]

STATINTL

STATINTL

[redacted]

STATINTL

dithering, diffusing screen works! [redacted]

grain disappears, resolution = diff. grating system ($\frac{1}{8}$" circle up to 2500 rpm) - ampl. down?

distortion eliminated; orig image not improved;

any light source usable; GAL study) - noise problem, but mag. drive?

STATINTL

shaking diff. grtg won't elim. [redacted] but rotating would improve the averaging;

P done w. [illegible]'s gratings?

[redacted] can do w. 2" easily; should they? (our funds)

STATINTL

STATINTL

[redacted] anxious for 25K retention funds soon; tie w. them to retain Viewer (ship-in-place)

some extra funds expended above target, but funds below ceiling remain

STATINTL

[redacted] TSD (2 [redacted] contracts)

STATINTL

Let TSD know when final tests are

2nd set of optics utilized to compare oscillating screen w. rotation of diff. gratings ?
(answer at later date)

Zoom capability in future ?

STATINTL multiple audience w. osc. screen

[redacted] will call Monday on add-costs for rotation study, time-

STATINTL

MEMORANDUM RECEIPT

22 October 1965
DATE

TO: [redacted]

FRO [redacted]

SUBJECT: GFE Loan

I hereby acknowledge receipt of the following:

One (1) 11" x 11" Micro Flat Glass Plate Bearing $10\frac{1}{2}$" x $10\frac{1}{2}$" corssed Phase Grating, Experimental Plate #281.

STATINTL ESTIMATED VALUE: [redacted]

STATINTL

Please return 2 [redacted]s) of this receipt

To [redacted] Box 8031

[redacted] DC 20044

SIGNATURE OF RECIPIENT

DATE RECEIVED

FORM NO. 752 REPLACES FORM 36-66
1 AUG 55 WHICH MAY BE USED.

(33)

[redacted]

rulings in [illegible]

intensity increases toward ctr
no superimposed sinusoidal
70 l/mm res (geor) + screen
stripe in low contrast
200 l/mm for high

rulings crossed

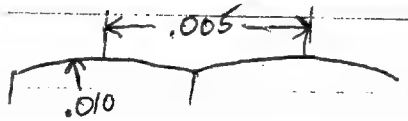
4" dia circle exit pupil;
dark ring $\frac{3}{4}$" wide mid-way
out (variation not sudden)
subjective appearance good;
lines seen at low contrast
(poor); 70 l/mm

exit-pupil size o.k.
but higher quality needed

[redacted] not contactable yet;
no letter either yet

STATINTL

[redacted]

200 l/in 

(lenticular screen?)

diff. bet. grating + lent. screen?
obj. to diffract into many orders of spectrum (13 on either side of
12th - 14th order critical (72 μ groove
½ diff. for 1st order
STATINTL
Blaze + must distribute light equally in all orders
[redacted] chal original study on ± 6 orders
facets made for each order within 33 μ groove
illum not even enough
Direct Viewer 256 l/mm at 1.6 contrast
does lentic. screen just smear image instead of multiplying?
since diffrac. principle used, narrow part of spectrum
STATINTL
needed - [redacted] has been trying to avoid diff. in lent. work
bandwidth dys to 670 mμ actually possible in practice [redacted]
50% overlap of exit pupils gives intensity uniformity +
less sensitivity to color differences

STATINTL

STATINTL

[redacted] (?) gets int. obstruc. w. lent. screen

STATINTL outside lenses; [redacted] says lent screen ~~outside~~ bet. lenses would do trick

STATINTL diff. grating w. blaze ∠ of circle = lent screen?

[redacted] special embossing process can vary orders attained - "Cone Screen" - spacings randomized to eliminate diff. + color effects - (2 90° gratings unnecessary)

end product desired:- 3-4" exit pupil from .280" e.p. at no image degradation. (diffusion screen rather than diff. grating gives only 70 l/mm?)

Recordak microfilm readers use screens without large lenses because of costs

(our viewer has d.g.'s on either side of field lens)

use of Fresnel lens? (50" f.l. needed) master cost?

STATINTL [redacted] could collect many pieces of plastic lent screens "lying around" + test them all at [redacted] STATINTL

STATINTL [redacted] Fresnel lens continuous spiral w. varying black & uniform brightness ~ parallel lt. thru screen STATINTL

"#.50 apiece for lent sheets from [redacted]

cheap Fresnel lens could replace 1/6 field lens } exit pupil increased further?

Need operator to move head to get max. intens. at particl. spots, cost could be cut

STATINTL Specs given [redacted] 1.6:1 contrast, 5-6 lp/mm on screen
50" f.l. + 20" f.l. on 2 1/6" lenses,
exit pupil $3\frac{1}{2}$" - 4" square (or 2" × 4", etc.)
.280" orig exit pupil; 508 mm dia of spectrum
10-15 mc bandwidth; adjacent brightness
level diffs < 3:1, overall 4:1
pitch on dot. screen could change 5% without
spectral degrad. as w. diff. g.

STATINTL [redacted] 8" machine capability at present on crossed
screens; no such limit on directional - neither commercially
available now

STATINTL scintillation problem in white light in [redacted] present
screen research

crossing dot. screen more closely simulate diff. gtg.
but no light in some areas - solution would be to change
radius in rel. to spacing

STATINTL machinery at [redacted] would have to be reactivated -
who would pay tab?

NO capability beyond 8" (length of)

STATINTL

1) phase at 1300 Fri about 8", etc. (16" would require Fresnel Lens)

2) phone results of tests next week at [redacted] w. received material (specular screen = diff. grating)

↳ crossed could be made beyond 8"×8" but not core" (unidir.); 8" × 10" format possible (exit pupil same)

or randomized

3) if results +, visit from [redacted] (within mo.?)

STATINTL

answers by end of year (visit in Oct.)

uniform field function of pitch/radius + index of refraction

[redacted] - Virtual Image Viewer

STATINTL [redacted]

STATINTL [redacted]

STATINTL [redacted] 5x virtual image viewer terminated

May '63 - [redacted] got 16" breadboard contract

May '64 : 1- Engineering model for P.I. into 5x + 50x

10" x 10" viewing area

uniformity of light pattern [redacted] grating derived

STATINTL

2 optical systems & gratings

STATINTL [redacted] builds optics, [redacted] gratings

2" x 2" grating first, then 10" x 10" divided upon (8"

STATINTL [redacted] made photo-etched 10" grating

STATINTL [redacted] coming out w. cheap gratings soon,

STATINTL STATINTL

STATINTL [redacted] investigating

STATINTL [redacted] should send grating within 2 weeks to

STATINTL [redacted] will bring viewer to [redacted] or our plant (la

folding viewer box possible for fu

100x also possible [redacted] alcove)

Check on bldg. clearance

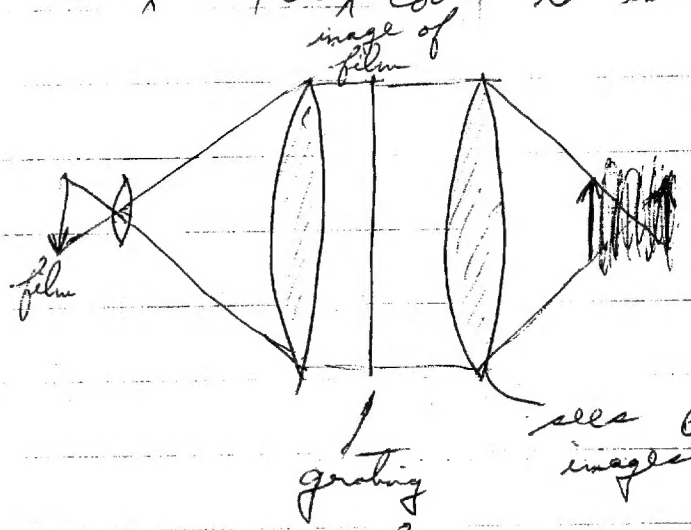
Where can $\frac{1}{2}$" f.? lens for 100x be obtained

Do we want 100x? interchangeable lens?

STATINTL

at 100x, brightness variation in diff. pts of exit pupil would result as diffraction squares become abutting instead of overlapping

50x + 100x could be interchangeable (50x not best)



13 orders either side of 0 diffracted w. overlapping, 6 orders w. abutting

4:1 intensity variation at exit pupil is max. acceptable

at 100x film leaves eye without interference filter (white light) at max I (absorption filters don't absorb enough IR)

if possible would white light be desirable?

(yes!)

STATINTL [redacted]

STATINTL Send Rep 100 l/mm ± chip if possible

[redacted] - less bldr.

crosshair reticle for locating at 5x - could be submerged in field flattener not yet gone at 50X

great advantage is high resolution at low contrast (200 l/mm @ 1.6/1 contrast) - impossible to achieve on diffusion screen

STATINTL [redacted] 23 Sept.

STATINTL 60 days [redacted] greetings!

— Corsica? [redacted] STATINTL

ILLEGIB

— future film translation [redacted]

STATINTL [redacted]

— Do they want 0-520 ℓ/mm target?
will not be on film ② 0-260 light

Next 4 Page(s) In Document Exempt